WHAT IS CLAIMED IS:

1. A thin film magnetic head comprising a protuberance layer having a predetermined length in the height direction from a surface facing a recording medium and a back gap layer located at a predetermined distance in the height direction from the rear end surface in the height direction of the protuberance layer, each provided on a lower core layer extending in the height direction from the facing-surface side, a magnetic layer connecting between the protuberance layer and the back gap layer, and a coil layer wound in a toroidal shape around the magnetic layer,

wherein a plurality of first coil pieces extending in the direction intersecting the magnetic layer are provided at predetermined spacings in the height direction in a space enclosed with the lower core layer, the protuberance layer, and the back gap layer, connection layers are provided while protruding from the end portions in the track-width direction of each first coil piece, and the first coil pieces are covered with a coil insulating layer,

wherein all of the top surface of the coil insulating layer, the top surface of the protuberance layer, the top surface of the back gap layer, and the top surfaces of the connection layers are provided as the same flattened surface,

wherein the magnetic layer is provided on the flattened surface of the coil insulating layer, the protuberance layer, and the back gap layer,

wherein a plurality of second coil pieces crossing over

the magnetic layer are provided on the magnetic layer with an insulating layer therebetween, and

wherein the end portions in the track-width direction of each second coil piece are electrically connected to the top surfaces of the connection layers exposed at the flattened surface, and the end portions of the first coil pieces adjacent to each other are connected via the second coil pieces, so that the coil layer wound in a toroidal shape is provided.

2. A thin film magnetic head comprising a protuberance layer having a predetermined length in the height direction from a surface facing a recording medium and a back gap layer located at a predetermined distance in the height direction from the rear end surface in the height direction of the protuberance layer, each provided on a lower core layer extending in the height direction from the facing-surface side, a magnetic layer connecting between the protuberance layer and the back gap layer, and a coil layer wound in a toroidal shape around the magnetic layer,

wherein a plurality of first coil pieces extending in the direction intersecting the magnetic layer are provided in a space enclosed with the lower core layer, the protuberance layer, and the back gap layer, and the first coil pieces are covered with a coil insulating layer,

wherein the magnetic layer is provided on the coil insulating layer, the protuberance layer, and the back gap layer, and the magnetic layer is covered with an insulating

layer having the top surface provided as a flattened surface,

wherein a plurality of second coil pieces crossing over the magnetic layer are provided on the flattened surface of the insulating layer, and

wherein the top surfaces of the connection layers electrically connected to the end portions in the track-width direction of each first coil piece are exposed at the surface flush with the flattened surface, the end portions in the track-width direction of each second coil piece are electrically connected to the top surfaces of the connection layers and, thereby, the end portions of the first coil pieces adjacent to each other are connected via the second coil pieces, so that the coil layer wound in a toroidal shape is provided.

3. A thin film magnetic head comprising a protuberance layer having a predetermined length in the height direction from a surface facing a recording medium and a back gap layer located at a predetermined distance in the height direction from the rear end surface in the height direction of the protuberance layer, each provided on a lower core layer extending in the height direction from the facing-surface side, a magnetic layer connecting between the protuberance layer and the back gap layer, and a coil layer wound in a toroidal shape around the magnetic layer,

wherein a plurality of first coil pieces extending in the direction intersecting the magnetic layer are provided in a space enclosed with the lower core layer, the protuberance

layer, and the back gap layer, lower connection layers are provided while protruding from the end portions in the track-width direction of each first coil piece, and the first coil pieces are covered with a coil insulating layer,

wherein all of the top surface of the coil insulating layer, the top surface of the protuberance layer, the top surface of the back gap layer, and the top surfaces of the lower connection layers are provided as the same flattened surface,

wherein the magnetic layer is provided on the flattened surface of the coil insulating layer, the protuberance layer, and the back gap layer, and upper connection layers electrically connected to the lower connection layers are provided,

wherein the magnetic layer is covered with an insulating layer having the top surface provided as a flattened surface, and the top surfaces of the upper connection layers are exposed at surfaces flush with the flattened surface, and

wherein a plurality of second coil pieces crossing over the magnetic layer are provided on the flattened surface of the insulating layer, the end portions in the track-width direction of each second coil piece are electrically connected to the upper connection layers exposed at the flattened surface, and the end portions of the first coil pieces adjacent to each other are connected via the second coil pieces, so that the coil layer wound in a toroidal shape is provided.

4. The thin film magnetic head according to Claim 1, wherein a laminated structure comprising a lower magnetic pole layer, a gap layer, and an upper magnetic pole layer for serving as the magnetic layer in that order from the bottom is provided on the protuberance layer, and a track width Tw is determined by the width dimension in the track-width direction of the laminated structure in the facing-surface.

5. The thin film magnetic head according to Claim 1, wherein the protuberance layer is a magnetic pole end layer in which at least a lower magnetic pole layer, a gap layer formed from a non-magnetic metal material, and an upper magnetic pole layer are provided by plating in that order from the bottom and a track width Tw is regulated by the width dimension in the track-width direction in the facing-surface, and the magnetic layer is laminated on the magnetic pole end layer.

6. The thin film magnetic head according to Claim 5, wherein the saturation magnetic flux density of the magnetic layer is lower than that of the upper magnetic pole layer.

7. The thin film magnetic head according to Claim 1, wherein, with respect to at least one pair of the first coil pieces adjacent to each other, the distance between the end portions adjacent to each other in the height direction of the first coil pieces is larger than a minimum distance between the first coil pieces in the region overlapping the

magnetic layer.

8. The thin film magnetic head according to Claim 7, wherein the plurality of first coil pieces include portions parallel to each other in the region overlapping the magnetic layer.

9. The thin film magnetic head according to Claim 1, wherein, with respect to at least one pair of the second coil pieces adjacent to each other, the distance between the end portions adjacent to each other in the height direction of the second coil pieces is larger than a minimum distance between the second coil pieces in the region overlapping the magnetic layer.

10. The thin film magnetic head according to Claim 9, wherein the plurality of second coil pieces include portions parallel to each other in the region overlapping the magnetic layer.

11. The thin film magnetic head according to Claim 1, wherein the length dimension of the second coil piece in a first direction orthogonal to the direction of a current flow is larger than the length dimension of the first coil piece in the first direction.

12. The thin film magnetic head according to Claim 1, wherein the film thickness of the second coil piece is larger

than the film thickness of the first coil piece.

13. The thin film magnetic head according to Claim 2, wherein a laminated structure comprising a lower magnetic pole layer, a gap layer, and an upper magnetic pole layer for serving as the magnetic layer in that order from the bottom is provided on the protuberance layer, and a track width Tw is determined by the width dimension in the track-width direction of the laminated structure in the facing-surface.

14. The thin film magnetic head according to Claim 2, wherein the protuberance layer is a magnetic pole end layer in which at least a lower magnetic pole layer, a gap layer formed from a non-magnetic metal material, and an upper magnetic pole layer are provided by plating in that order from the bottom and a track width Tw is regulated by the width dimension in the track-width direction in the facing-surface, and the magnetic layer is laminated on the magnetic pole end layer.

15. The thin film magnetic head according to Claim 14, wherein the saturation magnetic flux density of the magnetic layer is lower than that of the upper magnetic pole layer.

16. The thin film magnetic head according to Claim 2, wherein, with respect to at least one pair of the first coil pieces adjacent to each other, the distance between the end portions adjacent to each other in the height direction of

the first coil pieces is larger than a minimum distance between the first coil pieces in the region overlapping the magnetic layer.

17. The thin film magnetic head according to Claim 16, wherein the plurality of first coil pieces include portions parallel to each other in the region overlapping the magnetic layer.

18. The thin film magnetic head according to Claim 2, wherein, with respect to at least one pair of the second coil pieces adjacent to each other, the distance between the end portions adjacent to each other in the height direction of the second coil pieces is larger than a minimum distance between the second coil pieces in the region overlapping the magnetic layer.

19. The thin film magnetic head according to Claim 18, wherein the plurality of second coil pieces include portions parallel to each other in the region overlapping the magnetic layer.

20. The thin film magnetic head according to Claim 2, wherein the length dimension of the second coil piece in a first direction orthogonal to the direction of a current flow is larger than the length dimension of the first coil piece in the first direction.

21. The thin film magnetic head according to Claim 2, wherein the film thickness of the second coil piece is larger than the film thickness of the first coil piece.

22. The thin film magnetic head according to Claim 3, wherein a laminated structure comprising a lower magnetic pole layer, a gap layer, and an upper magnetic pole layer for serving as the magnetic layer in that order from the bottom is provided on the protuberance layer, and a track width Tw is determined by the width dimension in the track-width direction of the laminated structure in the facing-surface.

23. The thin film magnetic head according to Claim 3, wherein the protuberance layer is a magnetic pole end layer in which at least a lower magnetic pole layer, a gap layer formed from a non-magnetic metal material, and an upper magnetic pole layer are provided by plating in that order from the bottom and a track width Tw is regulated by the width dimension in the track-width direction in the facing-surface, and the magnetic layer is laminated on the magnetic pole end layer.

24. The thin film magnetic head according to Claim 23, wherein the saturation magnetic flux density of the magnetic layer is lower than that of the upper magnetic pole layer.

25. The thin film magnetic head according to Claim 3, wherein, with respect to at least one pair of the first coil

pieces adjacent to each other, the distance between the end portions adjacent to each other in the height direction of the first coil pieces is larger than a minimum distance between the first coil pieces in the region overlapping the magnetic layer.

26. The thin film magnetic head according to Claim 25, wherein the plurality of first coil pieces include portions parallel to each other in the region overlapping the magnetic layer.

27. The thin film magnetic head according to Claim 3, wherein, with respect to at least one pair of the second coil pieces adjacent to each other, the distance between the end portions adjacent to each other in the height direction of the second coil pieces is larger than a minimum distance between the second coil pieces in the region overlapping the magnetic layer.

28. The thin film magnetic head according to Claim 27, wherein the plurality of second coil pieces include portions parallel to each other in the region overlapping the magnetic layer.

29. The thin film magnetic head according to Claim 3, wherein the length dimension of the second coil piece in a first direction orthogonal to the direction of a current flow is larger than the length dimension of the first coil piece

in the first direction.

30. The thin film magnetic head according to Claim 3, wherein the film thickness of the second coil piece is larger than the film thickness of the first coil piece.

31. A method for manufacturing a thin film magnetic head, comprising the steps of:

(a) forming a lower core layer extending in the height direction from the side of a surface facing a recording medium;

(b) forming a coil insulating substrate layer on the lower core layer and, thereafter, forming a plurality of first coil pieces extending in the direction intersecting the height direction, at predetermined spacings in the height direction, on the coil insulating substrate layer in a predetermined region;

(c) forming a protuberance layer from the facing-surface toward the height direction on the lower core layer while the location of the protuberance layer is suitable for avoiding contact with the first coil pieces, forming a back gap layer on the lower core layer while the location of the back gap layer is at a distance in the height direction from the rear end surface in the height direction of the protuberance layer and is suitable for avoiding contact with the first coil pieces, and forming connection layers protruding from the end portions in the track-width direction of each first coil piece;

(d) covering the first coil pieces with a coil insulating layer and, thereafter, polishing the coil insulating layer, the protuberance layer, the back gap layer, and the connection layers until the top surface of the protuberance layer, the top surface of the coil insulating layer, the top surface of the back gap layer, and the top surfaces of the connection layers are provided as the same flattened surface;

(e) forming a magnetic layer on the flattened surface of the coil insulating layer, the protuberance layer, and the back gap layer to connect between the protuberance layer and the back gap layer; and

(f) forming an insulating layer on the magnetic layer, forming a plurality of second coil pieces on this insulating layer while the second coil pieces cross over the magnetic layer, connecting the end portions in the track-width direction of each second coil piece to the top surfaces of the connection layers exposed at the flattened surface, and connecting the end portions of the first coil pieces adjacent to each other via the second coil pieces, so that a coil layer wound in a toroidal shape is provided.

32. The method for manufacturing a thin film magnetic head according to Claim 31, wherein the protuberance layer, the back gap layer, and the connection layers are simultaneously formed from the same material in the step (c).

33. The method for manufacturing a thin film magnetic head according to Claim 31, comprising, instead of the step

(f), the steps of:

(g) forming upper connection layers on the connection layers while the upper connection layers extend to the locations higher than the top surface of the magnetic layer;

(h) covering the magnetic layer with an insulating layer and, thereafter, polishing the insulating layer and the upper connection layers until the top surfaces of the upper connection layers and the top surface of the insulating layer are provided as the same flattened surface; and

(i) forming a plurality of second coil pieces on the flattened surface of the insulating layer while the second coil pieces cross over the magnetic layer, connecting the end portions in the track-width direction of each second coil piece to the top surfaces of the upper connection layers exposed at the flattened surface, and connecting the end portions of the first coil pieces adjacent to each other via the second coil pieces, so that a coil layer wound in a toroidal shape is provided.